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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

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| In re application of | : | **Confirmation No. 9834** |
| Hiroshi MURAKAMI et al. | : | Docket No. 00169/P22949-01(I.S.Nakano) |
| Serial No.09/520,149 | : | Group Art Unit 2834 |
| Filed March 7, 2000 | : | Examiner G. Perez |

PERMANENT MAGNET SYNCHRONOUS MOTOR

THE COMMISSIONER IS AUTHORIZED TO CHARGE ANY DEFICIENCY IN THE FEES FOR THIS PAPER TO DEPOSIT ACCOUNT NO. 23-0975



**APPELLANTS' BRIEF UNDER 37 CFR 1.192**

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

The following is the Appellant's Brief, submitted in triplicate and in accordance with the provisions of 37 CFR 1.192. In addition, a petition for a one-month extension of time, along with the necessary petition fee, is also enclosed.

## 1. REAL PARTY IN INTEREST.

The real party in interest is Matsushita Electric Industrial Co. Ltd, of Osaka, Japan, the assignee of the present invention.

## 2. RELATED APPEALS AND INTERFERENCES.

There are no known related appeals or interferences.

## 3. STATUS OF CLAIMS.

Claims 1- 48 have been cancelled, and claims 49-94 have been rejected in view of the prior art in the final Office Action of February 21, 2002. The rejection of these claims is appealed. A complete copy of the claims on appeal is provided in the Appendix.

4. **STATUS OF AMENDMENTS**.

No amendments subsequent to the final rejection of February 21, 2002 have been made.

5. **SUMMARY OF THE INVENTION**.

Conventional motors having distributed windings require complicated winding processes during manufacture, and also require rare earth magnets and sensors which greatly increase the cost of these motors (see paragraph 3 on page 1 of the specification). In view of these problems, the present invention is directed to permanent magnet synchronous motors that include stators having teeth and *concentrated* windings in which adjacent teeth have *different polarities* (and all of the claims recite these features). However, the opposite polarity of adjacent teeth in the stator creates an increased risk that the rotor will become demagnitized (see paragraph 10 on page 3 of the specification). Thus, the present invention is directed to permanent synchronous motors having concentrated windings as discussed above, and in which the stator and/or the rotor are arranged so as to significantly reduce or eliminate the possibility of demagnitizing the rotor without minimizing the torque output of the motor.

In one embodiment of the present invention, the rotor and the stator are arranged to meet the relationship: $0.3\ Lg < La \leq 2.0\ Lg$, in which La is the clearance between adjacent teeth of the stator 1 and Lg is the air gap 8 between the stator 1 and the rotor 2, as shown in Figure 1b and described in paragraphs 12 and 13 on pages 3 and 4 of the specification. The inventors have determined that a motor which meets this relationship will minimize the amount of leakage flux flowing toward the rotor 2 (caused by the concentrated windings), while also providing sufficient clearance to prevent the side edges of adjacent teeth from interfering with each other (see paragraph 13 on page 4 of the specification). Consequently, demagnetization of the permanent magnet 6 of rotor 2 is minimized or eliminated, while motor torque is maintained. These benefits are illustrated in the graph of Figure 2, showing the relationship between demagnetization and the ratio La/Lg.

In another embodiment of the present invention, the rotor and the stator are arranged to meet the relationship: $2\ Lg < Lb < 5\ Lg$, in which Lb is the depth of the edge of the tooth 4 of

stator 1 and Lg is the air gap 8 between the stator 1 and the rotor 2 as shown in Figure 3 and explained in paragraph 14 on page 4 of the specification. In this arrangement, the leakage flux from the stator toward the rotor 2 is also minimized, so as to minimize the potential for the rotor 2 to become demagnetized, while maintaining the torque output of the motor. Figures 4a and 4b illustrate the benefits of this arrangement, with reference to the description in paragraph 48 on page 9 of the specification. Of course, if the relationship in the first embodiment described above is combined with the relationship in the second embodiment described above are combined, the advantages are further increased (see paragraph 14 on page 4 of the specification).

In another embodiment of the invention as shown in Figure 5, at least one of the leading-side edge and the trailing-side edge of each of the teeth 4 have a bevel 9 formed at the first end closest to the rotor and have a protrusion formed at the second end farthest from the rotor so that the side edge of each tooth is maintained at a substantially constant depth (see paragraphs 50-54 on pages 9 and 10 of the specification). As a result of bevel 9 on the first end and the protrusion on the second end of each of the teeth 4, the amount of magnetic flux flowing toward the rotor 2 is minimized while the motor torque is maintained.

In addition to the modifications to the stator in order to reduce the risk of demagnetizing the rotor as described above, the present invention includes modifications to the arrangement of the rotor itself in order to reduce the risk of demagnetization while maintaining motor torque. Specifically, in another embodiment of the present invention shown in Figures 6 and 7 and described in paragraph 56 on page 10 of the specification, bevels 11 are formed on both edges of the permanent magnet 6 of the rotor 2 so as to form a recessed section at each side of the permanent magnet 6. Thus, as shown in Figure 7, the demagnetizing magnetic field 12 travels through the resulting open space created by the recess section, but the demagnetizing magnetic field 12 does not reach or demagnetize the permanent magnet 6, and motor torque is maintained.

Yet another embodiment of the present invention is illustrated in Figures 13 and 14 and described in paragraphs 67-69 on pages 13 and 14 of the specification. Specifically, the rotor 2 includes a rotor core 5 and a curved permanent magnet 18 buried in the rotor core along the core rim so that the center of curvature of the permanent magnet is *outside* the rotor, and so that a side

end of the permanent magnet faces the rotor rim from inside the rotor rim. The rotor 2 also includes a spacer 16 formed in the rotor at the side end of the curved permanent magnet 18 as shown in Figures 13 and 14. As with the previous embodiments, the arrangement of this embodiment minimizes the amount of magnetic flux from the stator that reaches the rotor so as to reduce or eliminate demagnetization of the rotor. Several additional examples of this embodiment are shown in Figures 16a-16f and described in paragraph 73 on page 15, and all of these arrangements also prevent demagnetization of the rotor without reducing torque output of the motor.

## 6. **ISSUES**.

The issue on appeal is whether claims 49-94 are obvious in view of the applied prior art. More particularly, are claims 49-66 obvious in view of the combination of the Applicant's Admitted Prior Art (AAPA) and European Patent No. 642210A1 ("the Takahashi reference"); are claims 67-71 obvious in view of the combination of the AAPA and U.S. Patent No. 1,761,836 ("the Macfarlane reference"); are claims 72-77 and 81-83 obvious in view of the combination of the AAPA and Japanese Patent No. 406245418A ("the Asai reference"); are claims 78-80 and 84-89 obvious in view of the combination of the AAPA, the Asai reference, and Japanese Patent No. 405304737 ("the Tanimoto reference"); and are claims 90-94 obvious in view of the combination of the AAPA and U.S. Patent No. 5,191,256 ("the Reiter reference").

## 7. **GROUPING OF CLAIMS**.

Claims 49-54 stand or fall together, but do not stand or fall with claims 55-94.

Claims 55-60 stand or fall together, but do not stand or fall with claims 49-54 and 61-94.

Claims 61-66 stand or fall together, but do not stand or fall with claims 49-60 and 67-94.

Claims 67-71 stand or fall together, but do not stand or fall with claims 49-66 and 72-94.

Claims 72-89 stand or fall together, but do not stand or fall with claims 49-71 and 90-94.

Claims 90-94 stand or fall together, but do not stand or fall with claims 49-89.

**8. ARGUMENT.**

Claims 49-54 Are Patentable Over The Prior Art.

In the final Office Action, the Examiner rejected claims 49-54, including independent claim 49, as being unpatentable over the AAPA in view of the Takahashi reference. Each of these claims recite that the rotor and stator are arranged to meet the relationship: $0.3\ Lg < La \leq 2.0\ Lg$, in which La is the clearance between adjacent teeth of the stator, and Lg is the air gap between the rotor and the stator. The AAPA of, for example, Figure 17 shows a permanent magnet synchronous motor 21 having a stator 22 with a concentrated winding 23 so that adjacent teeth 22, 22 have different polarities. The Examiner, however, notes that the AAPA does not disclose a rotor and a stator arranged to meet the recited relationship.

However, the Examiner asserts that column 13, lines 16-38 of the Takahashi reference discloses the recited relationship. The Applicants, however, respectfully disagree. In this regard, Figure 1 of the Takahashi reference indicates that "g" represents the air gap between the stator 1 and the rotor 2, while "s" appears to indicate the clearance between adjacent "teeth" of the stator. Although the Takahashi reference appears to disclose equations describing various relationships between the dimensions of the stator and/or the rotor, including, for example, the slot pitch "t", the clearance between adjacent teeth "s", the air gap "g", and the inner diameter of the stator "d" (see columns 8-12), the Takahashi reference does not, contrary to the Examiner's assertion, disclose or even suggest the relationship of the clearance between adjacent teeth of the stator La and the air gap between the rotor and the stator Lg as recited in independent claim 49.

Moreover, the Takahashi reference discloses a brushless DC motor with *distributed* windings 1c shown in Figure 1, rather than a stator having teeth with concentrated windings in which adjacent teeth have different polarities, as recited in claims 49-54. Thus, because the relationship recited in independent claim 49 is necessitated when *concentrated* windings are provided such that adjacent teeth have different polarities, the Takahashi reference would not provide any motivation to one with ordinary skill in the art to modify the AAPA so as to obtain the invention recited in claim 49 because the motors of the Takahashi reference do not encounter

the same problems overcome by the present invention. Therefore, it is respectfully submitted that claims 49-54 are not obvious in view of the AAPA and the Takahashi reference, and are patentable over the prior art of record..

Claims 55-60 Are Patentable Over The Prior Art.

In the final Office Action, the Examiner rejected claims 55-60, including independent claim 55, as being unpatentable over the AAPA in view of the Takahashi reference. Each of these claims recite that the rotor and stator are arranged to meet the relationship: $2\ Lg < Lb < 5\ Lg$, in which Lb is a depth of the side edge of each tooth, and Lg is an air gap between the rotor and the stator. In this regard, the Examiner noted that the AAPA does not disclose a rotor and a stator arranged to the recited relationship. However, the Examiner asserts that the Takahashi reference discloses this relationship. The Applicants, however, respectfully disagree. As indicated above with respect to claims 49-54, the Takahashi reference appears to disclose various relationships between the dimensions of the stator and/or the rotor. However, the Takahashi reference does not, contrary to the Examiner's assertion, disclose or even suggest the relationship of the side edge of each tooth of the stator Lb and the air gap between the rotor and the stator Lg as recited in independent claim 55.

Moreover, as discussed above with respect to claims 49-54, the Takahashi reference discloses a brushless DC motor with *distributed* windings 1c shown in Figure 1, rather than a stator having teeth with concentrated windings in which adjacent teeth have different polarities, as recited in claims 55-60. Therefore, the Takahashi reference would not provide any motivation to one with ordinary skill in the art to modify the AAPA so as to obtain the invention recited in independent claim 55 because the motors of the Takahashi reference do not encounter the same problems overcome by the present invention. Therefore, it is respectfully submitted that claims 55-60 are not obvious in view of the AAPA and the Takahashi reference, and are patentable over the prior art of record.

Claims 61-66 are patentable over the prior art.

In the final Office Action, the Examiner rejected claims 61-66, including independent claim 61, as being unpatentable over the AAPA in view of the Takahashi reference. Each of these claims recite that the rotor and stator are arranged to meet *both* of the relationships: $2\ Lg < Lb < 5\ Lg$ *and* $0.3\ Lg < La \leq 2.0\ Lg$, in which La is the clearance between adjacent teeth of the stator, Lb is a depth of the side edge of each tooth, and Lg is an air gap between the rotor and the stator. As indicated above with respect to claims 49-54 and 55-60, however, the Takahashi reference does not, contrary to the Examiner's assertion, disclose or even suggest *either* of the relationships recited in independent claim 61.

Moreover, as also discussed above with respect to claims 49-54 and 55-60, the Takahashi reference discloses a brushless DC motor with *distributed* windings 1c shown in Figure 1, rather than a stator having teeth with concentrated windings in which adjacent teeth have different polarities, as recited in claims 61-66. Therefore, the Takahashi reference would not provide any motivation to one with ordinary skill in the art to modify the AAPA so as to obtain the invention recited in independent claim 61 because the motors of the Takahashi reference do not encounter the same problems overcome by the present invention. Accordingly, it is respectfully submitted that claims 61-66 are not obvious in view of the AAPA and the Takahashi reference, and are patentable over the prior art of record..

Claims 67-71 are patentable over the prior art.

In the final Office Action, the Examiner rejected claims 67-71, including independent claim 67, as being unpatentable over the AAPA in view of the Macfarlane reference. Independent claim 67 is directed to a permanent magnet synchronous motor comprising a rotor and a stator. The stator has teeth and concentrated windings so that the adjacent teeth have different polarities. The leading-side edge and/or the trailing-side edge of each of the teeth has a bevel formed at a first end closest to the rotor and has a protrusion formed at the second end farthest from the rotor so that the side edge of each tooth is maintained a substantially constant depth.

The Examiner acknowledged that the AAPA does not disclose or suggest a motor in which the leading-side edge and/or the trailing-side edge has a bevel and a protrusion so that the side edge of each tooth is maintained at a substantially constant depth. However, the Examiner asserts that the Macfarlane reference discloses teeth of a motor in which the leading-side edge and/or the trailing-side edge has a bevel formed at a first end closest to the rotor and has a protrusion formed at the second end farthest from the rotor. However, the Applicants respectfully disagree. Figures 1-5 of the Macfarlane reference appear to disclose teeth $P^1$ having a projection $L^t$ extending from a leading-side edge of the tooth, and having a projection $T^t$ extending from a trailing-side edge of the tooth. However, contrary to the Examiner's assertion, the Macfarlane reference does not disclose or suggest a bevel formed at a first end of the edge closest to the rotor, and does not disclose or suggest that the protrusion is formed at the second end of the side farthest from the rotor, as clearly shown in the figures of the reference.

Moreover, the Macfarlane reference relates to a dynamo and a magnetic winding of a DC machine, rather than to a motor having a stator with concentrated windings. The Macfarlane reference, therefore, is not concerned with reducing demagnetization of permanent magnets in a rotor. Thus, one of ordinary skill in the art would not be motivated by the Macfarlane reference to modify the AAPA so as to obtain the invention recited in independent claims 67-71. Accordingly, it is respectfully submitted that claims 67-71 are not obvious in view of the AAPA and the Macfarlane reference, and are patentable over the prior art of record..

Claims 72-89 are patentable over the prior art.

In the final Office Action, the Examiner rejected independent claim 72 as being unpatentable over the AAPA in view of the Asai reference, and several dependent claims as being unpatentable over the AAPA, the Asai reference, and the Tanimoto reference. Independent 72 is directed to a permanent magnet synchronous motor comprising a rotor and a stator having teeth and concentrated windings so that the adjacent teeth have different polarities. The rotor has a rotor rim and includes a permanent magnet arranged along the rotor rim. The permanent magnet

has an inwardly-tapered section formed at each side of its outer wall so as to form a recess section at each side of the permanent magnet.

The Examiner acknowledged that the AAPA does not disclose an inwardly-tapered section formed at each side of the outer wall of a permanent magnet so as to form a recess section at each side of the permanent magnet. However, the Examiner asserts that the Asai reference teaches an inwardly-tapered section 62a formed at each side of the outer wall so as to form a recess section at each side of the permanent magnet 62. However, the rotor 6 having the grooves 62a is used in a motor that includes a stator 4 having *distributed* windings as shown in Figure 1. Therefore, the motor of the Asai reference does not encounter the same problems generated by a stator having *concentrated* windings as in the present invention. In addition, the Tanimoto reference does not disclose or suggest the arrangement of the rotor as recited in independent claim 72. Therefore, one of ordinary skill in the art would not be motivated by the Asai reference or the Tanimoto reference to modify the AAPA so as to obtain the invention recited in independent claim 72. Accordingly, it is respectfully submitted that claims 72-79 are not obvious in view of the AAPA, the Asai reference, and the Tanimoto reference, and are patentable over the prior art of record..

Claims 90-94 are patentable over the prior art.

In the final Office Action, the Examiner rejected claims 90-94, including independent claim 90, as being unpatentable over the AAPA in view of the Reiter reference. Independent claim 90 is directed to a permanent magnet synchronous motor that includes a rotor and a stator having teeth and concentrated windings so that the adjacent teeth have different polarities. The rotor includes a curved permanent magnet buried in a rotor core and arranged along the core rim of the core so that the center of curvature of the permanent magnet is outside the rotor, and so that the side end of the permanent magnet faces the rotor rim from inside the rotor rim. The rotor also includes a spacer formed in the rotor at the side end of the permanent magnet.

The Examiner acknowledges that the AAPA does not disclose a rotor including a curved permanent magnet buried in a rotor core along the core rim of the rotor so that the center of

curvature of the permanent magnet is outside the rotor, and so that the side end of the permanent magnet faces the rotor rim from inside the rotor rim, and in which the rotor includes a spacer formed in the rotor at the side end of the permanent magnet. However, the Examiner asserts that the Reiter reference discloses a rotor core 40 and a permanent magnet 17 arranged so that the center of curvature of the permanent magnet 17 is outside the rotor 40 and so that the side end of the permanent magnet 17 faces the rotor rim from inside the rotor rim. In addition, the Examiner asserts that the Reiter reference discloses a space 95 formed in the rotor 40 at the side end of the permanent magnet 17.

However, as described in column 6, lines 13-43 and shown in Figures 5 and 6 of the Reiter reference, the rotor is arranged in a motor having a stator 60 with *distributed* windings. Therefore, the problems associated with stators having concentrated windings as in the present invention would not develop in the Reiter reference. Therefore, one of ordinary skill in the art would not be motivated by the Reiter reference to modify the AAPA so as to obtain the invention recited in independent claim 90. Accordingly, it is respectfully submitted that claims 90-94 are not obvious in view of the AAPA and the Reiter reference, and are patentable over the prior art of record..

**9. <u>APPENDIX</u>.**

A copy of the claims on appeal is set forth in an Appendix immediately following the conclusion and signature, and is incorporated herein by reference.

**CONCLUSION**.

In view of the above, it is respectfully submitted that claims 49-94 are not obvious in view of the combination of prior art references applied by the Examiner. Accordingly, the Board is requested to reverse the rejections set forth in the Final Office Action of February 21, 2002.

This brief is submitted in triplicate with the requisite fee of $320.00.

Respectfully submitted,

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## 9. APPENDIX - Claims on Appeal.

49. A permanent magnet synchronous motor comprising:

a rotor; and

a stator having teeth and concentrated windings such that adjacent teeth have different polarities;

wherein said rotor and said stator are arranged such that $0.3 \text{ Lg} < \text{La} \leq 2.0 \text{ Lg}$, wherein:

La is a clearance between said adjacent teeth of said stator; and

Lg is an air gap between said rotor and said stator.

50. The motor of claim 49, wherein said rotor includes a ferrite permanent magnet.

51. The motor of claim 49, wherein said stator includes a divided core.

52. The motor of claim 49, wherein said rotor and said stator are adapted to operate sensor-free.

53. An apparatus comprising:

a compressor in one of an air-conditioner and an electric refrigerator; and

the motor of claim 49 for driving said compressor.

54. The motor of claim 49, wherein said rotor and said stator are arranged such that Lg is not greater than 0.6 mm.

55. A permanent magnet synchronous motor comprising:

a rotor; and

a stator having teeth and concentrated windings such that adjacent teeth have different polarities;

wherein said rotor and said stator are arranged such that 2 Lg < Lb < 5 Lg, wherein:

Lb is a depth of a side edge of each tooth; and

Lg is an air gap between said rotor and said stator.

56. The motor of claim 55, wherein said rotor includes a ferrite permanent magnet.

57. The motor of claim 55, wherein said stator includes a divided core.

58. The motor of claim 55, wherein said rotor and said stator are adapted to operate sensor-free.

59. An apparatus comprising:

a compressor in one of an air-conditioner and an electric refrigerator; and

the motor of claim 55 for driving said compressor.

60. The motor of claim 55, wherein said rotor and said stator are arranged such that Lg is not greater than 0.6 mm.

61. A permanent magnet synchronous motor comprising:

a rotor; and

a stator having teeth and concentrated windings such that adjacent teeth have different polarities;

wherein said rotor and said stator are arranged such that $0.3\ Lg < La \leq 2.0\ Lg$ and such that $2\ Lg < Lb < 5\ Lg$, wherein:

La is a clearance between said adjacent teeth of said stator;

Lb is a depth of a side edge of each tooth; and

Lg is an air gap between said rotor and said stator.

62. The motor of claim 61, wherein said rotor includes a ferrite permanent magnet.

63. The motor of claim 61, wherein said stator includes a divided core.

64. The motor of claim 61, wherein said rotor and said stator are adapted to operate sensor-free.

65. An apparatus comprising:

a compressor in one of an air-conditioner and an electric refrigerator; and

the motor of claim 61 for driving said compressor.

66. The motor of claim 61, wherein said rotor and said stator are arranged such that Lg is not greater than 0.6 mm.

67. A permanent magnet synchronous motor comprising:

a rotor; and

a stator having teeth and concentrated windings such that adjacent teeth have different polarities, each of said teeth having a leading-side edge and a trailing-side edge with respect to a rotation of said rotor, at least one of said leading-side edge and said trailing-side edge having a bevel formed at a first end closest to said rotor and having a protrusion formed at a second end farthest from said rotor such that each side edge of each tooth is maintained at a substantially constant depth.

68. The motor of claim 67, wherein said rotor includes a ferrite permanent magnet.

69. The motor of claim 67, wherein said stator includes a divided core.

70. The motor of claim 67, wherein said rotor and said stator are adapted to operate sensor-free.

71. An apparatus comprising:

a compressor in one of an air-conditioner and an electric refrigerator; and

the motor of claim 67 for driving said compressor.

72. A permanent magnet synchronous motor comprising:

a rotor having a rotor rim and including a permanent magnet arranged along said rotor rim, said permanent magnet having an outer wall with respect to a radial direction of said rotor, an inwardly-tapered section being formed at each side of said outer wall with respect to the radial direction of said rotor so as to form a recessed section at each side of said permanent magnet; and

a stator having teeth and concentrated windings such that adjacent teeth have different polarities.

73. The motor of claim 72, wherein said rotor and said stator are adapted to operate sensor-free.

74. An apparatus comprising:

a compressor in one of an air-conditioner and an electric refrigerator; and

the motor of claim 72 for driving said compressor.

75. The motor of claim 72, wherein said stator and said rotor are arranged such that 0.10 As < Am < 0.25 As, wherein:

Am is an angle of an arc length of said tapered section at each side of said outer wall of said permanent magnet measured with respect to a central axis of said rotor; and

As is an angle of an arc length of each tooth measured with respect to the central axis of said rotor.

76. The motor of claim 75, wherein said rotor and said stator are adapted to operate sensor-free.

77. An apparatus comprising:

a compressor in one of an air-conditioner and an electric refrigerator; and

the motor of claim 75 for driving said compressor.

78. The motor of claim 72, wherein said permanent magnet has an inner wall with respect to a radial direction of said rotor, said inner wall having a flat face such that a width with respect to a radial direction of a center section of said permanent magnet is greater than a width of a side section.

79. The motor of claim 78, wherein said rotor and said stator are adapted to operate sensor-free.

80. An apparatus comprising:

a compressor in one of an air-conditioner and an electric refrigerator; and

the motor of claim 78 for driving said compressor.

81. The motor of claim 72, wherein said inwardly-tapered section formed at each side of said outer wall of said permanent magnet comprises a bevel formed at each side such that said recessed section is formed at each side of said permanent magnet, said rotor further including a rotor core, said permanent magnet being mounted on an outer wall of said rotor core.

82. The motor of claim 81, wherein said rotor and said stator are adapted to operate sensor-free.

83. An apparatus comprising:

a compressor in one of an air-conditioner and an electric refrigerator; and
the motor of claim 81 for driving said compressor.

84. The motor of claim 72, wherein said inwardly-tapered section formed at each side of said outer wall of said permanent magnet comprises a bevel formed at each side, said rotor further including a rotor core having a core rim, said permanent magnet being buried in said rotor core along said core rim.

85. The motor of claim 84, wherein said rotor and said stator are adapted to operate sensor-free.

86. An apparatus comprising:
a compressor in one of an air-conditioner and an electric refrigerator; and
the motor of claim 84 for driving said compressor.

87. The motor of claim 72, wherein said rotor further includes a rotor core having a core rim, said permanent magnet being buried in said rotor core along said core rim, said rotor core further including a spacer in said recessed section formed at each side of said permanent magnet.

88. The motor of claim 87, wherein said rotor and said stator are adapted to operate sensor-free.

89. An apparatus comprising:
a compressor in one of an air-conditioner and an electric refrigerator; and
the motor of claim 87 for driving said compressor.

90. A permanent magnet synchronous motor comprising:

a rotor having a rotor rim, said rotor including a curved permanent magnet and a rotor core having a core rim, said permanent magnet being buried in said rotor core along said core rim such that a center of curvature of said permanent magnet is outside said rotor and such that a side end of said permanent magnet faces said rotor rim from inside said rotor rim, said rotor further including a spacer formed in said rotor at said side end of said permanent magnet; and

a stator having teeth and concentrated windings such that adjacent teeth have different polarities.

91. The motor of claim 90, wherein said rotor and said stator are arranged such that $Lg < Q < 3\ Lg$, wherein:

Q is a distance between said side end of said permanent magnet and said rotor rim; and

Lg is an air gap between said rotor and said stator.

92. The motor of claim 90, wherein said stator and said rotor are arranged such that $0.10\ As < Am < 0.25\ As$, wherein:

Am is an angle of an arc length of said spacer at said side end of said permanent magnet measured with respect to a central axis of said rotor; and

As is an angle of an arc length of each tooth measured with respect to the central axis of said rotor.

93. The motor of claim 90, wherein said rotor and said stator are adapted to operate sensor-free.

94. An apparatus comprising:

a compressor in one of an air-conditioner and an electric refrigerator; and

the motor of claim 90 for driving said compressor.--

## ABSTRACT

The present invention provides a permanent-magnet-synchronous-motor having a stator with concentrated windings with the following structure so that permanent magnet (6) is hard to subjected to demagnetization magnetic field: $0.3\ Lg < La \leqq 2.0\ Lg$, where La is a clearance between teeth of stator (1), and Lg is an air-gap between stator (1) and rotor (2). Outer walls of both ends of the permanent magnet (6) disposed within rotor (2) in a rim direction may be tapered toward inside from a rotor rim in a radial direction and to form a recessed section on the outer walls of the magnets. As a result, withstanding force against demagnetization is expected to increase.